



## CLINICAL SUCCESS OF THE LIGHT-CURED CALCIUM SILICATE-BASED BIOMIMETIC MATERIAL FOR INDIRECT DENTAL PULP CAPPING AT SIX MONTHS

Sultan Saeed Alqahtani<sup>1\*</sup>, Mohammed Abdulrahman AlQahtani<sup>2</sup>, Nasser Mohammed Almutairi<sup>3</sup>, Yousef Saleh Alanazi<sup>4</sup>, Mshari Suliman Al Mutairi<sup>5</sup>, Nasser Tayeb Marir<sup>6</sup>, Saeed Ali Alqahtani<sup>7</sup>, Mohammed Saeed Alasiri<sup>8</sup>, Turki Abdullah M AlQarni<sup>9</sup>, Saeed Ateeq kh. Al Zahrani<sup>10</sup>

<sup>1\*,2,3,4,5,6,7,8,9,10</sup>General dentist at ministry of health

\*Corresponding author: Sultan Saeed Alqahtani

\*General dentist at ministry of health

### Abstract

**Background:** Biomimetic, bioinspired, and bioactive synthetic materials aim to replicate natural processes to address issues or substitute existing structures.

**Aim:** This meta-analysis study's primary goal was to investigate biomimetics in restorative dentistry.

**Patients and Methods:** The Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) criteria were both followed by this research. Based on the following PICO question components, the search strategy was created and executed utilizing the PubMed restricted vocabulary and free keywords. The Cochrane Risk of Bias Assessment Tool 1 (ROB1) was used to assess the quality of the included studies.

**Results:** No variations in clinical outcomes between the teeth treated using light-cured calcium silicate or other calcium-based materials were found in our meta-analysis of the clinical outcomes of indirect pulp capping in permanent teeth at six months. A statistically substantial variation favoring the control group was seen in our meta-analysis of the clinical effectiveness of indirect pulp capping in permanent teeth utilizing a light-cured calcium silicate-based material at 12 months.

**Conclusion:** There was no discernible variation between the controls and TheraCal LC in the available evidence for direct pulp capping in permanent teeth. After a year, indirect pulp capping in permanent teeth demonstrated a statistically significant variation that was in favor of the control group. Furthermore, since there was a chance of bias in the included research, the evidence's confidence ranged from low to moderate.

**Keywords:** Biomimetic, Restorative dentistry, Indirect dental pulp capping, Meta-analysis

### Introduction

The study of biomimetics focuses on the shape and function of biological products, which are created by biological processes and mechanisms needed to create synthetic materials that resemble biological tissues. (1). The word "biomimetic" was first used in the 1950s by biophysicist and biomedical engineer Otto Herbert Schmitt, during his interdisciplinary investigation into the biological development of a substance that resembles living things. The understanding of teeth serves as the foundation for this content. (2).

In dentistry, the construction of tooth structure is not the only concept that is adhered to; it also establishes the function, stress-bearing capacity, and aesthetics of the tooth. The study of biomimetics focuses on the evolution of natural principles into technology tools, procedures, and structures, ranging from biological to technical. It was successful to create a material that is inventively generated during the whole abstraction process. Nanofiller materials are used in dentistry to boost the longevity of dental restorative materials. (3).

The two key traits that draw attention to biomimetics are their capacity to regenerate biological tissue and their capacity to repair the biological effects of these tissues. (4). Nonetheless, the goal of both of these attributes is to replicate the biological characteristics of the tooth via restoration. The material's modulus of elasticity and purpose should correspond with the dental tissue (e.g., pulp, dentin, enamel, and dentinoenamel junction). Cell-homing techniques for pulp formation Applications of biomimetic endodontic regeneration include cell-homing, apexogenesis, pulp-capping agent renewing dentin barrier, apexification leading to root development, and root-end fillings resulting in apical healing. (5).

Biomimetic, bioinspired, and bioactive synthetic materials aim to replicate natural processes to address issues or substitute existing structures. TheraCal LC (Bisco, Schaumburg, IL, USA) is a commercially available light-cured resin modified with tricalcium silicate filler particles that is a recent introduction to the biomimetic biomaterial market. Poly(ethylene glycol) dimethacrylate, portland cement type III, bis-GMA, and barium zirconate make up the majority of the TheraCal LC biomaterial. (6).

This meta-analysis study's primary goal was to investigate biomimetics in restorative dentistry.

## Methods

Our research aligned with the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Items for Reporting for Systematic Reviews and Meta-analyses (PRISMA) criteria.

### Literature search

In order to try to establish the studies that referred to biomimetics in restorative dentistry, an online search for appropriate research was conducted, including PubMed indexed literature. The search was performed by combining the terms "Bio-mimetic" and "regeneration" using the AND operator, occasionally adding the terms "restorative treatment methods" and "biomimetic restorative materials." The terms "biomimetics," "dental biomaterials," "restorative dentistry," and "dentistry" were among them. Utilizing the keywords "biomimetic materials" and "tissue engineering," further searches were conducted on Google Scholar and Semantic Scholar.

### Eligibility criteria

Based on the following components of the PICO question, the search strategy was created and executed utilizing the PubMed restricted vocabulary and free terms: According to the date the substance was first put on the market, investigations conducted in vitro or in vivo that were written in English and published within the past 20 years meet the eligibility requirements. To achieve a standardization of the cavity that would not be achievable in an in vivo investigation, it was chosen to include both in vitro and human tooth studies.

### Data gathering

Using an offline data extraction sheet, relevant information was methodically gathered from each included research as part of the data extraction procedure. The information that was extracted included a range of elements, including the name and year of publication of the first author, the research's location, patient numbers, the gender distribution, participant ages, eligibility requirements, study findings, and main outcomes.

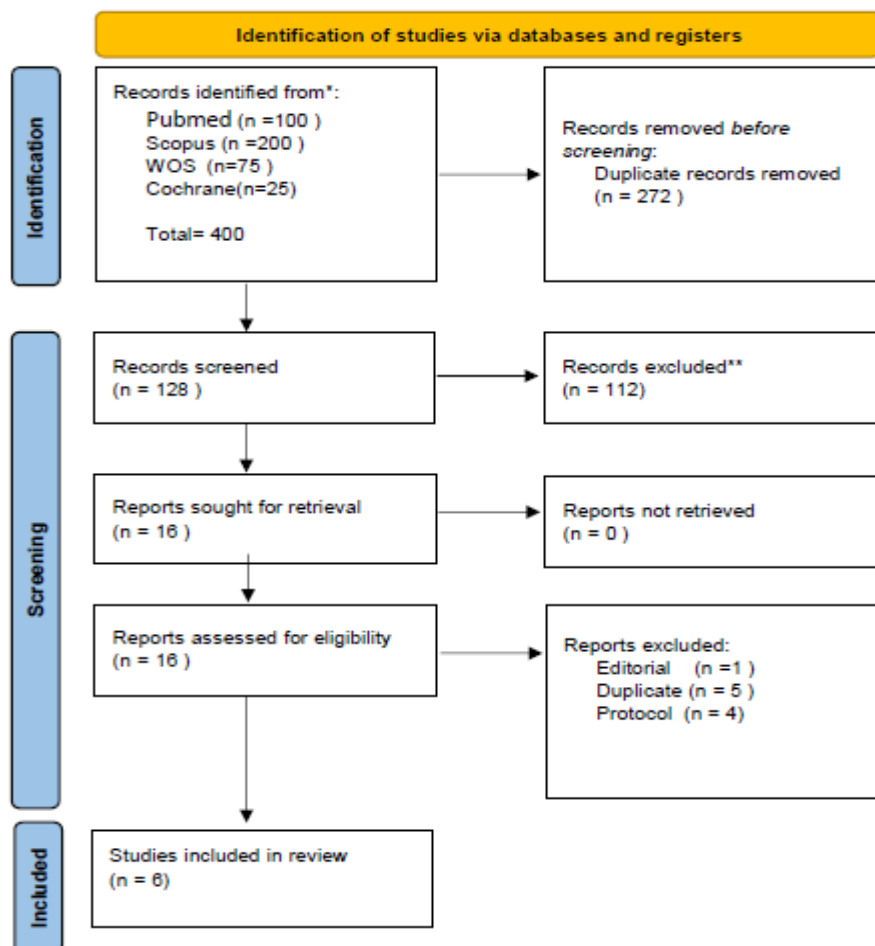
### Risk of bias assessment

Specifically created for evaluating interventional research, the ROB1 was used to evaluate the quality of the included trials. There are many settings on this tool. These criteria included biases related to reporting, performance, selection, attrition, detection, and other likely causes of bias. Every domain underwent a thorough examination to guarantee a thorough assessment of any possible biases present in the included research. The evaluation's quality was rated by the authors as "good," "fair," or "poor." A number of variables were carefully considered before this categorization was decided upon. Conflicts that arose during the assessment stage were successfully resolved by the investigators having discussions with one another or by enlisting the help of a third assessor.

### Data synthesis

We explicitly utilized the inverse variance technique for continuous outcomes in this meta-analysis. The mean differences (M.D.) between the two groups and their corresponding standard deviations (S.D.) were used in this procedure. In contrast, for the double-arm meta-analysis, categorical outcomes were aggregated as a relative risk (R.R.) between the two comparison groups with a 95% confidence interval (C.I.). We used Revman version 5.4 for our meta-analysis.

### Results



**Figure 1:** PRISMA 2020 flow diagram.

The first article search produced 400 items. 26 studies were examined for eligibility requirements out of the 178 total records that were requested for retrieval after duplication checks utilizing Endnote Reference Manager. We have eventually included six papers after applying the inclusion and exclusion standards. As per the flow diagram for systematic review of PRISMA 2020. Our six included trials containing patients with mean age 36 years old suffering from dental caries.

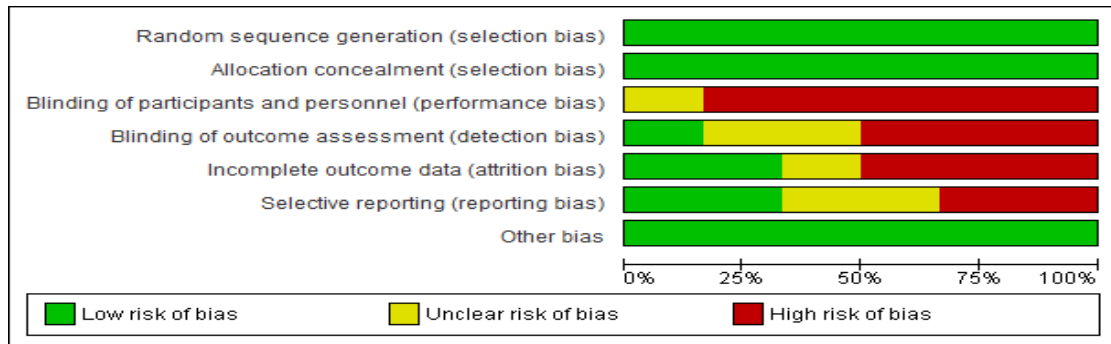


Figure 2: Risk of bias graph.

The selected studies showed a high rate of return on investment (ROB) when it came to blinding participants and staff to the outcome evaluation. Randomization and allocation concealment have low ROB. The majority of the research, unclear regarding detection and attrition biases, low in other biases.

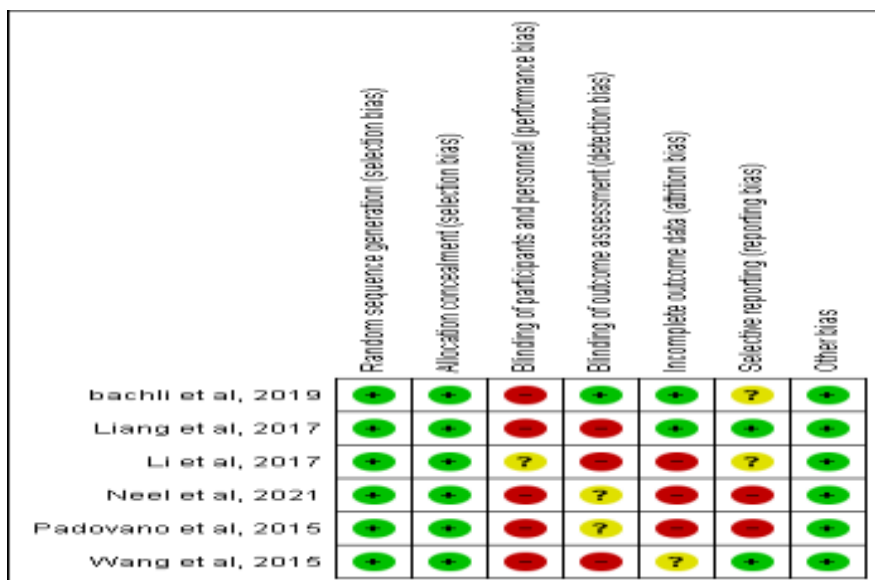


Figure 3: Risk of bias summary.

Figure 3: showed There was evidence of a reasonable quality, suggesting that the conclusions would be acceptable.

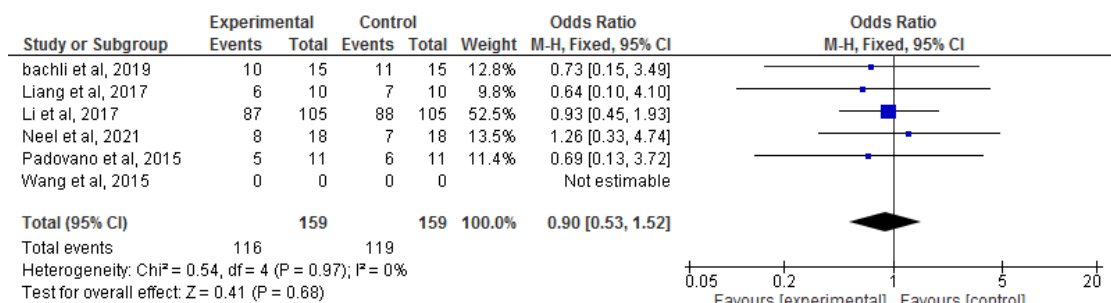
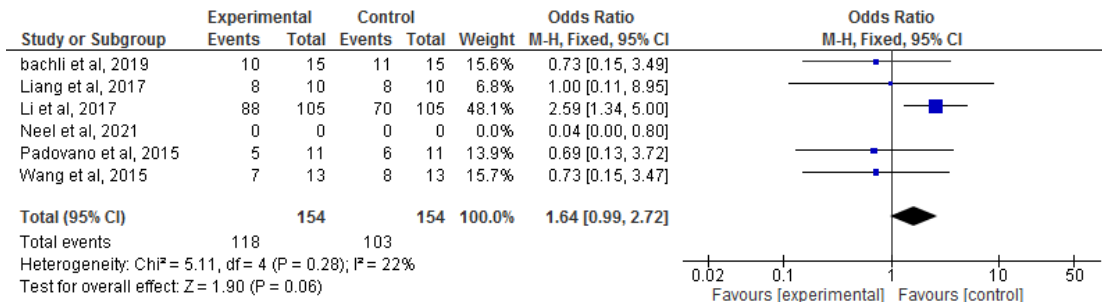


Figure 4: showed substance based on light-cured calcium silicate Six months later, direct pulp capping in permanent teeth.

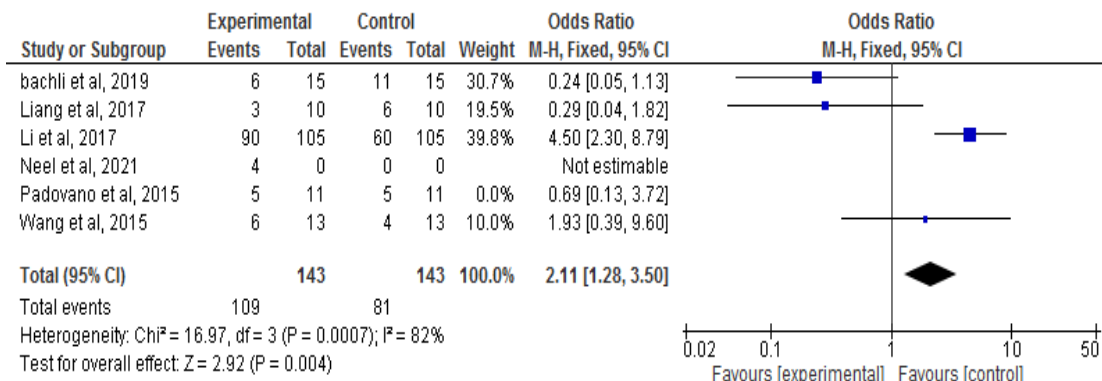
There were no variations in the clinical success between the teeth treated by light-cured calcium silicate and other calcium-based materials, according to a meta-analysis of the efficacy of the biomimetic material based on calcium silicate for indirect dental pulp capping at 6 months (Odds

Ratio 95%). Our pooled trials for this outcome showed homogeneity with  $\chi^2=0.97$ ,  $I^2=0\%$ , and  $CI = 0.9 [0.53, 1.52]$ ;  $p = 0.7$ .



**Figure 5:** showed Six months of indirect pulp closure in permanent teeth.

Our meta-analysis of the clinical success revealed that the outcomes showed no variations in the teeth treated by calcium silicate that has been light-cured or with other calcium-based materials (Odds Ratio 95%). Our pooled trials for this outcome showed homogeneity with  $\chi^2=0.28$ ,  $I^2=22\%$ , and  $CI = 1.64 [0.99, 2.7]$ ;  $p = 0.06$ ).



**Figure 6:** showed The clinical efficacy of a material cured with light and calcium silicate Twelve months of indirect pulp capping in permanent teeth.

Our pooled investigations for this result were substantially heterogeneous with  $\chi^2=0.0007$ ,  $I^2=82\%$ . Our meta-analysis of the clinical outcomes of indirect pulp capping in permanent teeth utilizing light-cured calcium silicate-based material at 12 months revealed that there was a clinically substantial distinction favoring the control group (Odds Ratio 95%  $CI = 2.11 [1.28, 3.5]$ ;  $p = 0.004$ ).

### Discussion

The term "biomimetic" comes from the Latin "bio," which means "life," and "mimetic," which refers to imitating or copying biological processes by drawing inspiration from natural phenomena. Understanding new biomimetics techniques has required thinking through concepts from the fields of materials science, bioengineering, biology, and chemistry. Furthermore, a significant push in the creation of biomimetic materials via the use of nanotechnology has been highlighted by a number of nanoscale material developments. The rise of biomimetic courses for undergraduate and graduate students in the fields of interdisciplinary teaching, robotics engineering, biomaterials, and industrial design is promising. Regarding this, **Cleymand et al.** spoke about the ideas and practical applications of biomimetic principles and tools for the creation of novel materials, enhanced design and production techniques, and innovative methods that are used with students enrolled in "biomimicry" courses. (7). The primary aim of this meta-analysis study was to study the biomimetics in restorative dentistry and after applying inclusion and exclusion criteria, we have finally included six studies.

When it comes to the biomimetic compound for indirect dental pulp capping at 6 months, there were no variations in the clinical outcomes of teeth treated using light-cured calcium silicate or other calcium-based compounds, per a meta-analysis. Indirect pulp capping in permanent teeth: a meta-analysis of its effectiveness at six months showed no differences in clinical outcome between teeth treated by light-cured calcium silicate or other calcium-based materials. There was a statistically substantial variation favoring the control group in our meta-analysis of the clinical effectiveness of compounds based on light-cured calcium silicate indirect pulp capping in permanent teeth at 12 months.

Our results were in agreement with meta-analysis held by **DA ROSA et al., (8)**, as They revealed that the studies were homogeneous ( $I^2 = 0\%$ ). They found that there were no variations in the clinical outcome between the patients who got the comparator biomaterials and TheraCal LC, a light-cured calcium silicate-based biomimetic biomaterial, for dental pulp capping ( $p > 0.5$ ).

Our results were supported by study of **Abou Neel et al., (9)**, as they reported that When dentin was subjected to an acidic challenge, it displayed a sub-surface partial demineralization of 100–300  $\mu\text{m}$  along with a ragged and totally demineralized surface layer of  $120 \pm 30 \mu\text{m}$ . Following an 8-week course of treatment with phosphate glass polyacrylate paste (PGPAP), an adhering layer of angular-like crystals fully remineralized virtually all dentinal tubules and inter-tubular dentin. This layer, which measured  $313 \pm 6 \mu\text{m}$  in thickness and contains Ca, P, Na, and Cu, represents the remineralization of almost all demineralized dentin.

Also, in the study of **Bächli et al., (10)**, verified the demineralized dentin's capacity for remineralization, particularly after the administration of dentin matrix proteins (DMP), however this did not surpass the performance of amine fluoride solution (AMF). This means that more research involving fluorides and proteins is now necessary and is being conducted.

Furthermore, **Li et al., (11)**, revealed that Tricalcium silicate (TCS) 50 showed greater efficiency in remineralization following 6 weeks when biomimetic analogs were added. The relative depth and intensity of remineralization were 76.6% and 79.7%, respectively, and were considerably higher than at 1 week (significance: TCS 50, an experimental cement based on TCS, demonstrated the ability to remineralize artificially demineralized dentin).

Moreover, **Wang et al., (12)**, reported the process of biomimetically remineralizing dentin by adding phosphate groups to poly(amidoamine) (PAMAM) dendrimers using a modified multifunctional dendrimer that is created by a Mannich-type reaction. They demonstrated how phosphorylated PAMAM dendrimers could effectively phosphorylate demineralized dentinal collagen fibrils, and how remineralization might result in the embedding of calcium-deficient hydroxyapatite. Additionally, high biocompatibility was found.

In addition, **Padovano et al., (13)**, suggested that Peptides produced from dentin matrix protein 1 (DMP1) may be helpful in controlling mineral deposition and the subsequent production of hydroxyapatite (HA) when subjected to normal calcium and phosphate values.

As well, **Liang et al., (14)**, concluded that When traditional remineralization techniques like PAMAM or NACP failed, dentin remineralization using poly (amido amine) (PAMAM) 1 nanoparticles of amorphous calcium phosphate (NACP) adhesive in pH4 and CaP-lacking acid was accomplished for the first time. Even for individuals with dry mouth and an acidic oral environment, the innovative PAMAM 1 NACP technique shows promise in prolonging the life of the composite-tooth bond, preventing caries, remineralizing lesions, and safeguarding tooth structures.

## Conclusion

There was no discernible variation between the controls and TheraCal LC in the available evidence for direct pulp capping in permanent teeth. After a year, indirect pulp capping in permanent teeth demonstrated a statistically substantial variation that was in favor of the control group. Furthermore, since there was a chance of bias in the included research, the evidence's confidence ranged from low to moderate.

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